THE PROVENANCE AND DEPOSITIONAL SETTING OF THE TAKROUNA FORMATION (PERMEAN) AT NEALL MASSIF SOUTH, NORTH VICTORIA LAND, ANTARCTICA

A SENIOR THESIS:

Completed in fulfillment for the requirements of a Bachelor of Science in Geology from The Ohio State University

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I wish to express sincere thanks to Jim Collinson for providing me with the opportunity to visit Antarctica, and for his help on this paper.

Special thanks is given to Chuck Vavra for all the time he spent helping me with this project.

B.L.R.

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INTRODUCTION

The purpose of this paper is to suggest probable depositional setting and provenance of a sequence of Permian sandstone, shale, and conglomerate exposed near Neall Massif in North Victoria Land, Antarctica.

The section was measured and sixteen samples were collected by Dr. James W. Collinson, Noel R. Kemp and I on December 19, 1981. I have since examined seven thin sections from these samples.

The tentative name for the outcrop locality is Neall Massif South. It is located in North Victoria Land at the following coordinates: 165^{0} 5' east longitude, 72^{0} 9' south latitude. The outcrop occurs on an east-trending ridge located 4 km south of Neall Massif (fig. 2).

At this locality a 236 m-thick section of diamictite, shale, conglomerate, and sandstone was described, measured and sampled. Paleocurrent measurements were determined from abundant planar and trough cross-bedding in the sandstone.

REGIONAL GEOLOGY of NORTH VICTORIA LAND

The geologic setting of North Victoria Land consists of four general geologic terrians separated from one another by three major south and southwest - trending faults (Gair et al., 1969).

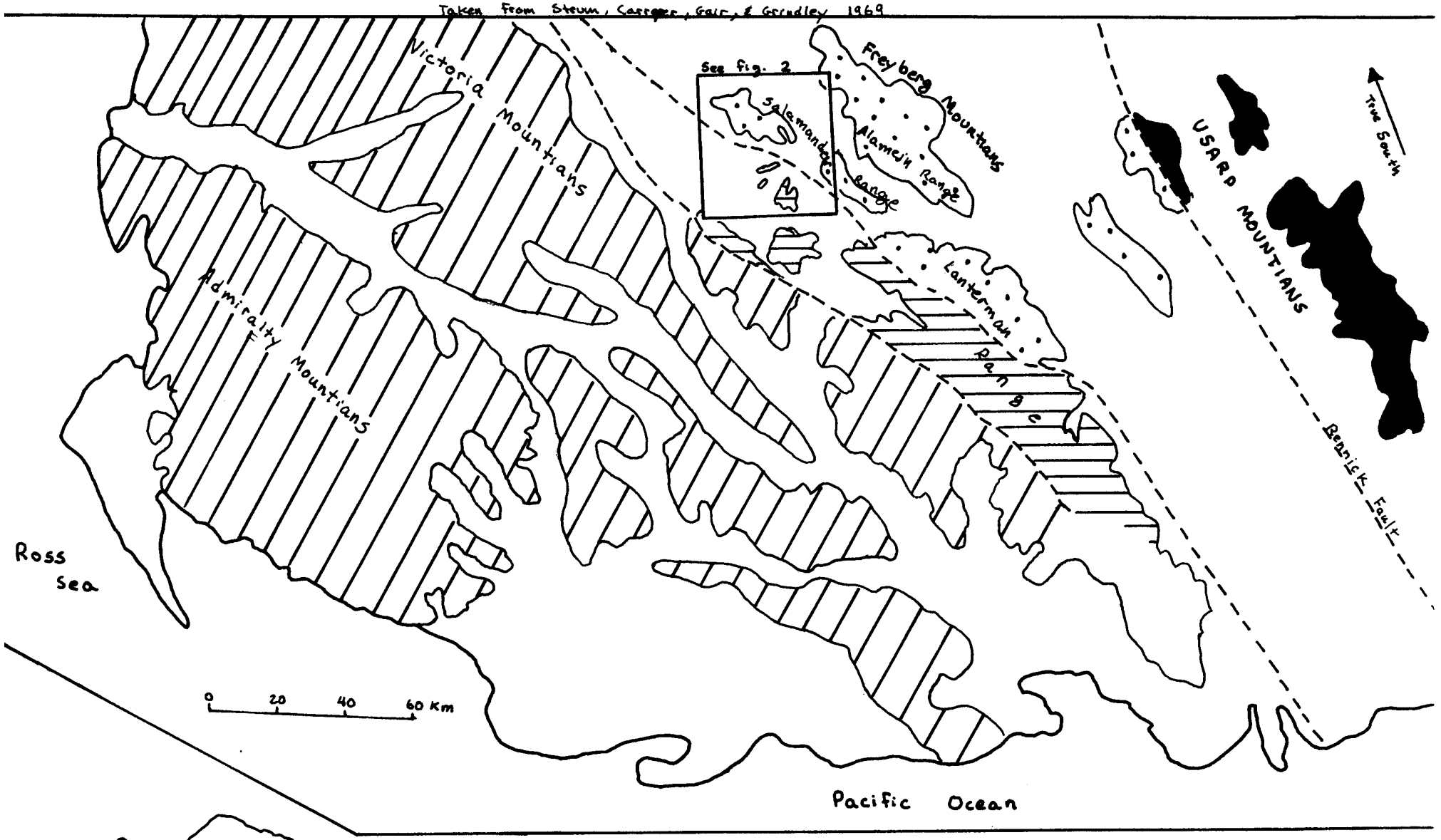
Eastward from the Ross Sea, the first rocks encountered are those of the Robertson Bay Group (fig. 1). These upper Precambrian rocks (Gunn, 1963) form the majority of the Admiralty and Victory Mountians. These are in places intruded by the Devonian and Carboniferous Admiralty Intrusives (Tessensohn et al., 1981) (Table 1). Toward the east a fault separates this terrain from one dominated by rocks of the Cambrian - Ordovician Bowers Group. These are accompanied by small outcrops of the Carboniferous - Triassic (Laird and Bradshaw, in press; Dow and Neall, 1974) Beacon Supergroup and the Jurassic Ferrar Group (Dow and Neall, 1974). Farther to the east this terrain is separated by a fault from the next geologic area consisting of rocks of the Precambrian Wilson Group, the Cambrian through Silurian Granite Harbour Intrusives (Gair et al., 1969; Tessensohn et al., 1981), the Beacon Supergroup, the Ferrar Group and the Admiralty Intrusives along with their extrusive equivalents, the Gallipoli Porphyries

(Dow and Neall,1974). Together these rocks form the Freyberg Mountians and the Morazumi Range. On the east side of the prominent Rennick Fault lies the fourth geologic terrain. This region contains the USARP Mountians and is bounded on the east by the Polar Plateau. The most common rocks in this area are those of the Wilson Group and the Granite Harbour Intrusives.

Fig. 1

NORTH VICTORIA LAND

Taken From Steum, Carrigan, Gair, & Grindley 1969



Location of Map above

---- Fault

Area 1 Robertson Bay Group, Admiralty Intrusives

Area 2 Bowers Group, Beacon Supergroup, Ferrar Group

Area 3 Wilson Group, Bowers Group, Robertson Bay Group, Granite Harbour Intrusi
Beacon Supergroup, Ferrar Group, Admiralty Intrusives, Gallipoli Porph

Area 4 Wilson Group, Granite Harbour Intrusives

Fig 1 North Victoria Land

TABLE 1

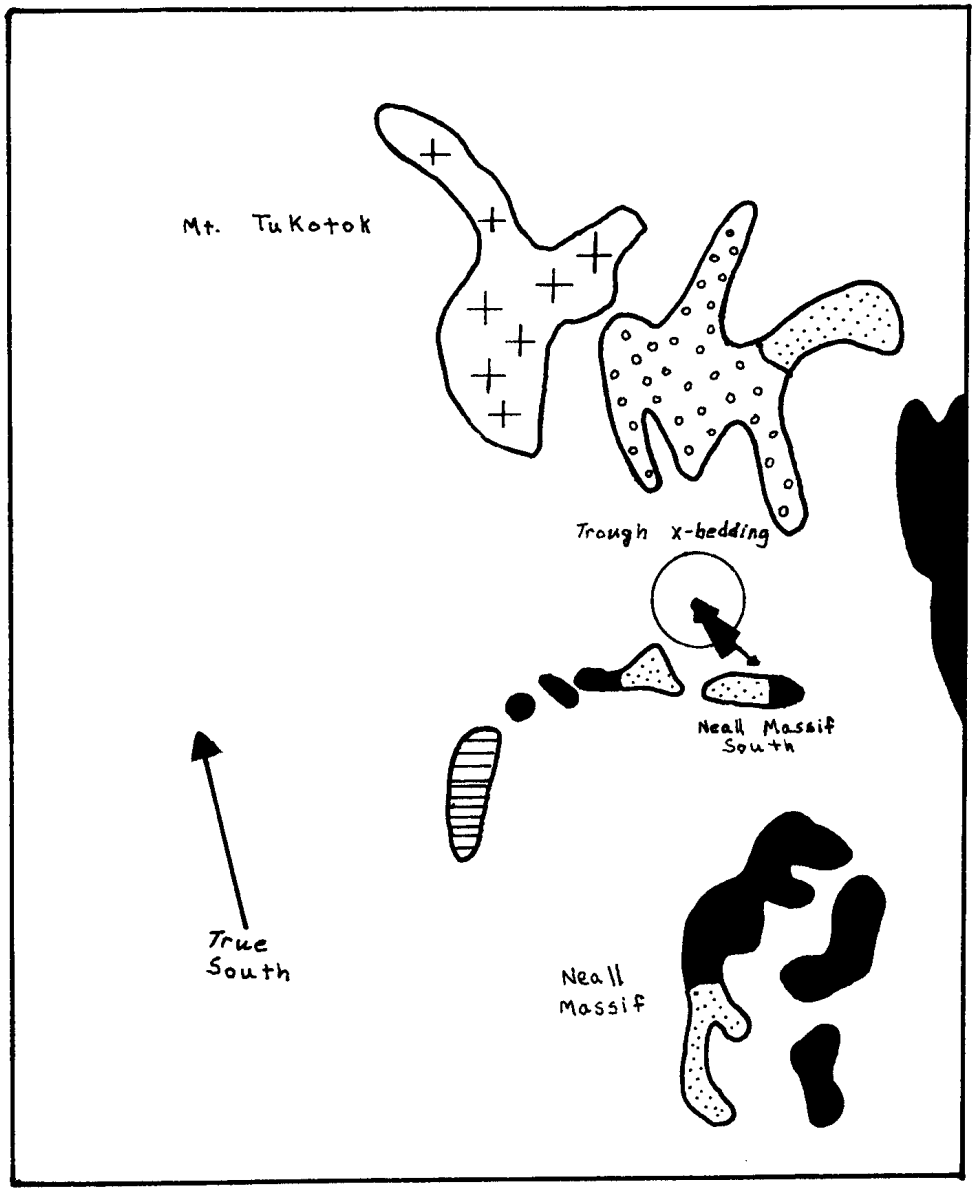
Major Rock Groups of North Victoria Land

Precambrian through Jurassic

(After Gair et al., 1969; Tessensohn et al., 1980; and Dow and Neall, 1974)

FERRAR GROUP	Jurassic	tholeiitic flood basalts, dolerite sills, and tuffs
BEACON SUPERGROUP (Takrouna Formation)	Triassic (?)-Permian	arkosic sandstones, carbonaceous shales, conglomerates, diamictites, and some tillites
GALLIPOLI PORPHYRIES	? Devonian	porphyritic rhyolites
ADMIRALTY INTRUSIVES	? Carboniferous-Devonian	granites and granodiorites, with aplitic and granophyic dikes
GRANITE HARBOUR INTRUSIVES	? Ordovician	biotite granite, granodiorites and diorites
BOWERS GROUP	? Ordovician-Cambrian	mafic volcanics, quartzites, limestone, quartzarenites, and conglomerate
ROBERTSON BAY GROUP	? Upper Precambrian	graywackes, slates, and argillite
WILSON GROUP	Precambrian	biotite- garnet paragneiss, with minor marble, biotite schists, and migmatites

Fig 2



Taken from Dow & Neall 1974
and
GANOVEX 1979/80

STRATIGRAPHY of the BEACON SUPERGROUP

Ferrar (1907) first used the term Beacon Sandstone in reference to the sandstone seen at Beacon Heights in Victoria Land. Later the Beacon was raised to group status by Harrington (1958). This was done to include all the sandstone sequences in Victoria Land similar to those at Beacon Heights. Harrington (1965) also proposed that the Beacon Group be subdivided into two divisions. One division would contain the lower quartzose strata which are Devonian and perhaps older in age, and a second division consisting of the upper carbonaceous and quartzofeldspathic beds which are Permian to Triassic in age. The lower group was named the Taylor Group and the upper, the Victoria Group. Between these two groups is the Maya Erosion Surface, an unconformity that represents a hiatus of most of the Carboniferous. Barrett (1971) suggested that the Beacon Sandstone be raised to Supergroup status because of its inclusion of the Victoria and Taylor Groups.

The name Takrouna Formation has been proposed by Dow and Neall (1974) for a sandstone sequence at Takrouna Bluff in the Alamein Range of North Victoria Land. The section at Takrouna Bluff consists of a 60 m-thick sequence of nearly horizontal beds of sandstone and

shale with lesser amounts of conglomerate and coal. The sandstone samples from this section studied by Dow and Neall, proved to be mostly feldspathic arenites. These are moderate - to well- sorted and contain angular to subrounded quartz grains. The amount of feldspar in these samples ranges from 20 to 60%. They reported that most of the feldspar is plagioclase, but one sample contained nearly equal amounts of potash - feldspar and plagioclase. Dow and Neall (1974) suggest a granite source area for these rocks.

The age of the Takrouna Formation is most likely Permian as indicated by the Glossopteris Flora which was found near the base of the section (Dow and Neall, 1974). Norris (in Sturm et al., 1970) reported a Late Triassic microflora at another locality in the Alamien Range, but this age assignment is suspect because this locality is also in the lower part of the Takrouna Formation (J. Collinson pers. comm.). Sediments of possible Permo - Carboniferous age have been reported immediately above tillites in the Lanterman Range of North Victoria Land (Laird and Bradshaw, in press). The composition and age of the Takrouna Formation substantiate its inclusion in the Victoria Group of the Beacon Supergroup.

NEALL MASSIF SOUTH SECTION DESCRIPTION

At the Neall Massif South locality, the sedimentary sequence consists of a 180 m-thick section of sandstone, shale, and conglomerate overlying 56 m of diamictite (see appendix). The lower contact of the diamictite was not exposed and therefore the reported thickness is incomplete.

The diamictite contains pebble - to cobble - sized, poorly - to well- rounded clasts of granite, schist, and fine - grained sandstone. These are scattered in a mudstone to very fine - grained sandstone which is dark - gray to dark olive - green. The upper contact of the diamictite is gradational up into a dark - gray carbonaceous shale which underlies the predominantly sandstone sequence above. Laterally, at the eastern end of the ridge, the sandstone sequence begins with a coarse - conglomerate that is channeled into the diamictite. The clasts in this conglomerate consist of cobble - to boulder - sized clasts of aplite which are well - rounded with a flattened spheroidal shape. These are contained in a coarse sandstone matrix.

The sandstone sequence at this locality consists predominantly of coarse - to medium - grained subangular to subrounded arkosic arenites (classification of Pettijohn, Potter, and Siever, 1972). Large scale trough and planar

cross - bedding are common with channel scours also being present. Clay drapes, linguoidal ripple casts, and possible mudcracks were also observed, but are uncommon. Pebble - to cobble - sized slasts of granite, quartzite, sandstone, mudstone, and fossil wood form thin conglomeratic lenses in the sandstone.

The sandstone forms fining upward sequences which commonly contain larger clasts in the basal scours, and are typically topped by shaley layers. These fining upward sequences are generally about 5 -7 m thick.

DEPOSITIONAL SETTING

The depositional setting for the Takrouna Formation at Neall Massif South was fluvial, as shown by the cyclical sequence with scoured base, abundant trough and planar cross - bedding, and terrestrial plant fragments. Collinson and Kemp (in press) suggest that the Beacon sediments in North Victoria Land were laid down by braided - stream systems which flowed into a northwest - trending basin. This braided - stream depositional system is also shown by the sequence at Neall Massif South.

In comparison with the Battery Point braided - stream sequence in Quebec (Cant and Walker, 1976), the sandstone at Neall Massif South has many characteristics of a braided - stream sequence. These characteristics include thick planar cross - bed units which consistantly have paleoflow directions at high angles to those indicated by the trough cross - bedding (fig. 3). These are formed by transverse bars migrating laterally across an active channel. The basal scours with associated clasts, fining upward sequence, small amount of vertical accretion deposits, and strong grouping of paleocurrent directions also indicate a braided - stream type system.

Laird and Bradshaw (in press) propose a fluvioglacial

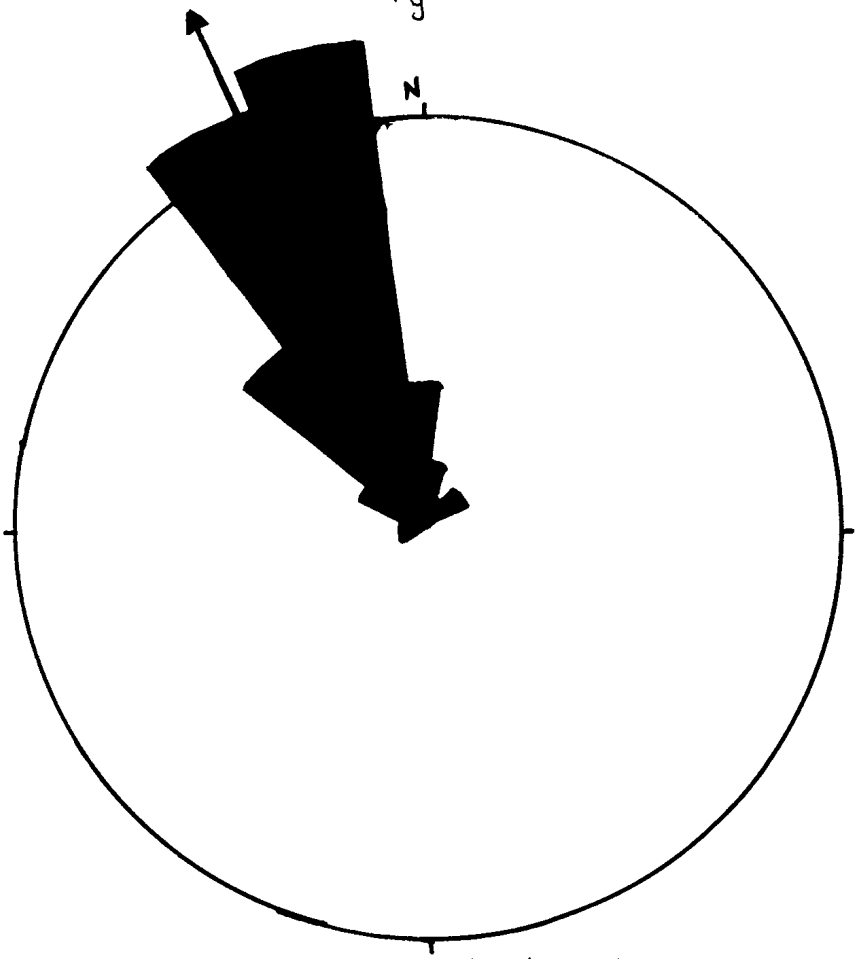
depositional setting for the sandstones, shales, and conglomerates which are associated with the tillites of the Lanterman Range. At this locality near the mouth of the Orr Glacier, they reported diamictite layers interbedded with sandstone, shale, and conglomerate. The uppermost diamictite passed sharply upward into a 30 m-thick mudstone sequence which then changes abruptly to a channel fill conglomerate. The conglomerate underlies a 110 m-thick sequence of cross - bedded sandstone which contains thin conglomerate layers and shale beds (Laird and Bradshaw, in press).

The fluvioglacial depositional setting suggested for the above sequence may also represent the type of setting shown at the base of the Neall Massif South section. This is shown by the overall similarity of these two sections as they pass from diamictite into thick sandstone sequences. The basal boulder - cobble conglomerate of the Neall Massif South section may represent glacial outwash deposits and the thick shale layer near the base may be pro-glacial lake deposits. Lack of evidence that the Neall Massif South diamictite is a tillite (eg. striated and faceted clasts) suggests that it is a mudflow or similar deposit associated with reworking of glacial deposits.

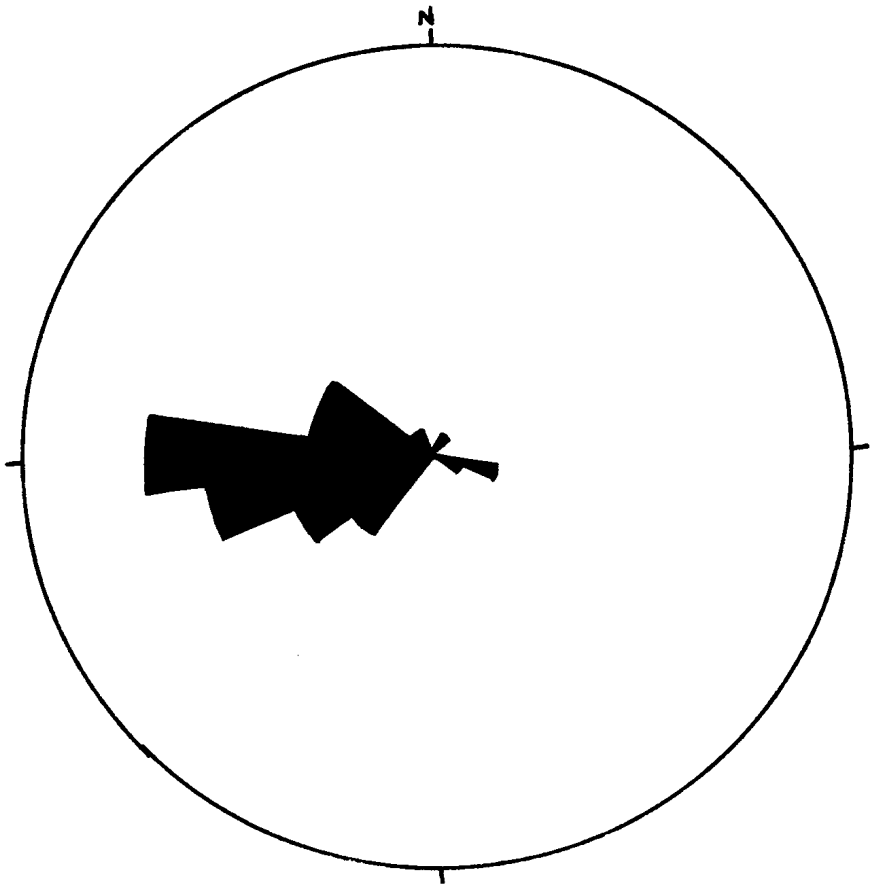
The sedimentary sequences at Neall Massif South probably represent a proximal depositional site near the margin of a northwest - trending basin (Collinson and

Kemp, in press). This depositional site was connected to the source area by a braided - stream system possibly preceeded by a glacially - sourced braided - stream system.

Fig 3



76 plotted
Trough cross-bedding only
Mean Vector Direction N24°W
L (% magnitude) 91%



Planar cross-bedding only, 57 plotted

PROVENANCE

The source area for the sediments at Neall Massif South appears to have been very close. This is shown by the angularity of the grains, the abundance and relatively low alteration of feldspar and by boulders and cobbles in the basal conglomerate. The relative proximity of the source area will also be affected by the type of depositional system. Sediments which were first glacially transported and then deposited by a fluvial system may have had a source area more distant than sediments linked to the source area by fluvial system only.

A granitic source area for the Beacon sediments in North Victoria Land has been suggested by Dow and Neall (1974), and by Collinson and Kemp (in press). This is again confirmed by the Beacon Sandstones at Neall Massif South.

A granitic source area for the Neall Massif South sandstones is shown by the relative abundance of feldspar and by the high potassium feldspar / plagioclase ratio. Granitic provenance is also shown by the aplitic and granitic composition of the clasts in the conglomeratic layers of the sequence.

Because of the bimodal nature of the trough and planar cross - bedding directions (fig. 3), it is thought

that the trough cross - bedding is a better indicator of current flow direction whereas the planar sets represent transverse bars migrating laterally across the channel. The trough cross - bedding indicates that the braided - stream system for Neall Massif South flowed from the southeast to the northwest (fig. 3).

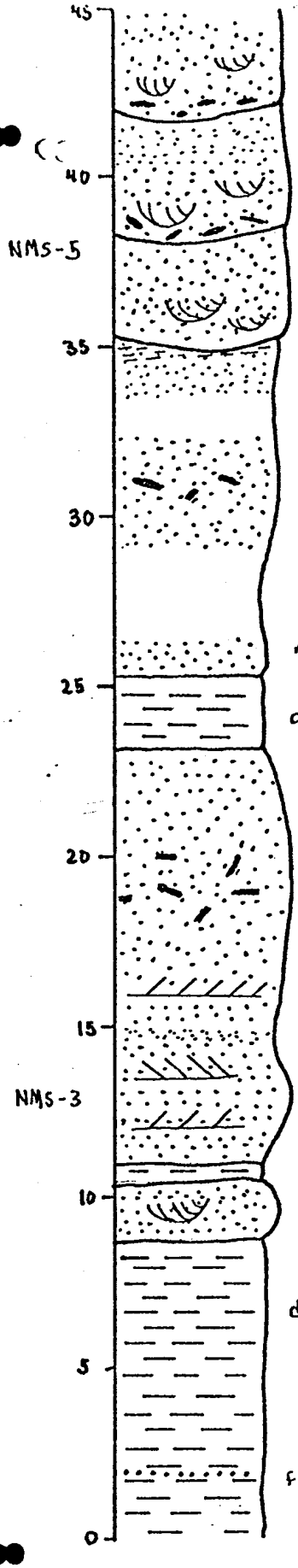
Mount Tukotok lies 10 km south - southeast of Neall Massif South and is composed of granodiorites of the Admiralty Intrusive Group (fig. 2). These granitic rocks have the following average estimated composition: 35% quartz, 25% perthitic alkali feldspar, 30% oligoclase plagioclase, and 10% which is biotite, chlorite and others. Aplitic veins assiciated with these intrusives are also found near Mount Tukotok.

The compositional similarities between the Mount Tukotok granodiorites and the detrital sediments of Neall Massif South are apparent (see thin section descriptions in appendix). The lower amount of plagioclase in the sediments is possibly due to weathering at source and during transport.

The compositional similarities together with the paleocurrent directions, and proximity of Mount Tukotok, strongly suggest the Admiralty Intrusives exposed on Mount Tukotok as a possible source area for the Beacon sediments at Neall Massif South.

APPENDIX I

STRATIGRAPHIC COLUMN
AND
PHOTOS



coarse grain sandstone, Trough cross-bedding, clasts of fine grain sandstone and mudstone

fine grain sandstone, thinly bedded

coarse to medium grain sandstone, sub-angular, trough cross-bedding, clasts of dark olive-gray mudstone and fine grain sandstone 1-2 cm, max. 10 cm

coarse grain sandstone, trough cross-bedding
Fine grain carbonaceous sandstone
fine grain sandstone, thinly bedded

medium grain sandstone, trough cross-bedding, coarse lenses, mudstone clasts

medium grain sandstone, carbonaceous at base

carbonaceous shale

medium to fine grain sandstone, thinly bedded

coarse grain sandstone, clasts of fine grain sandstone

medium grain sandstone, trough cross-bedding sets 20 cm

coarse to medium grain sandstone, planar cross-bedding

medium to fine grain sandstone, trough cross-bedding, ripple-laminated, partially carbonaceous

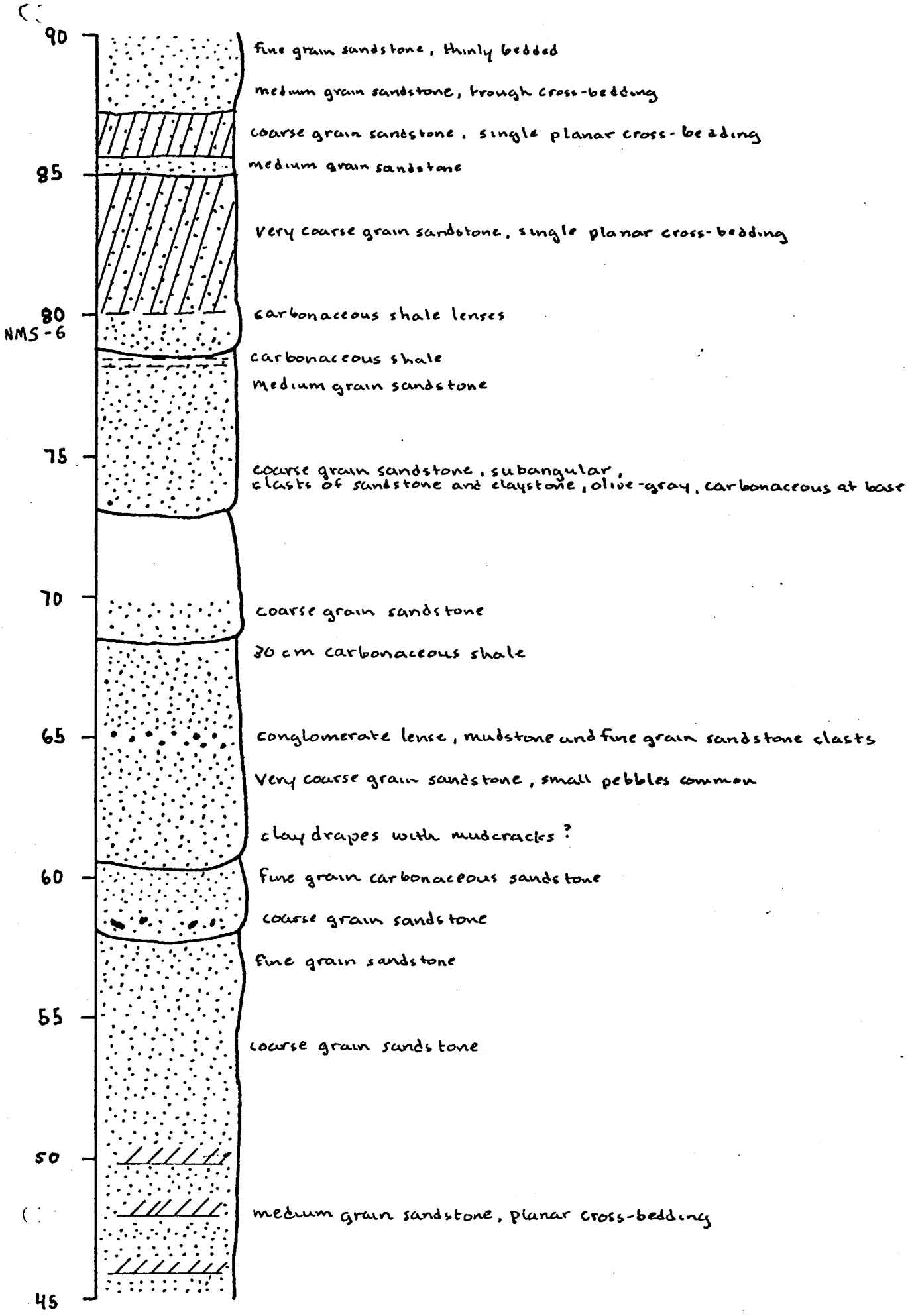
coarse grain sandstone, subangular, planar cross-bedding; pebbly lenses gray mudstone clasts, 2 cm quartz pebbles

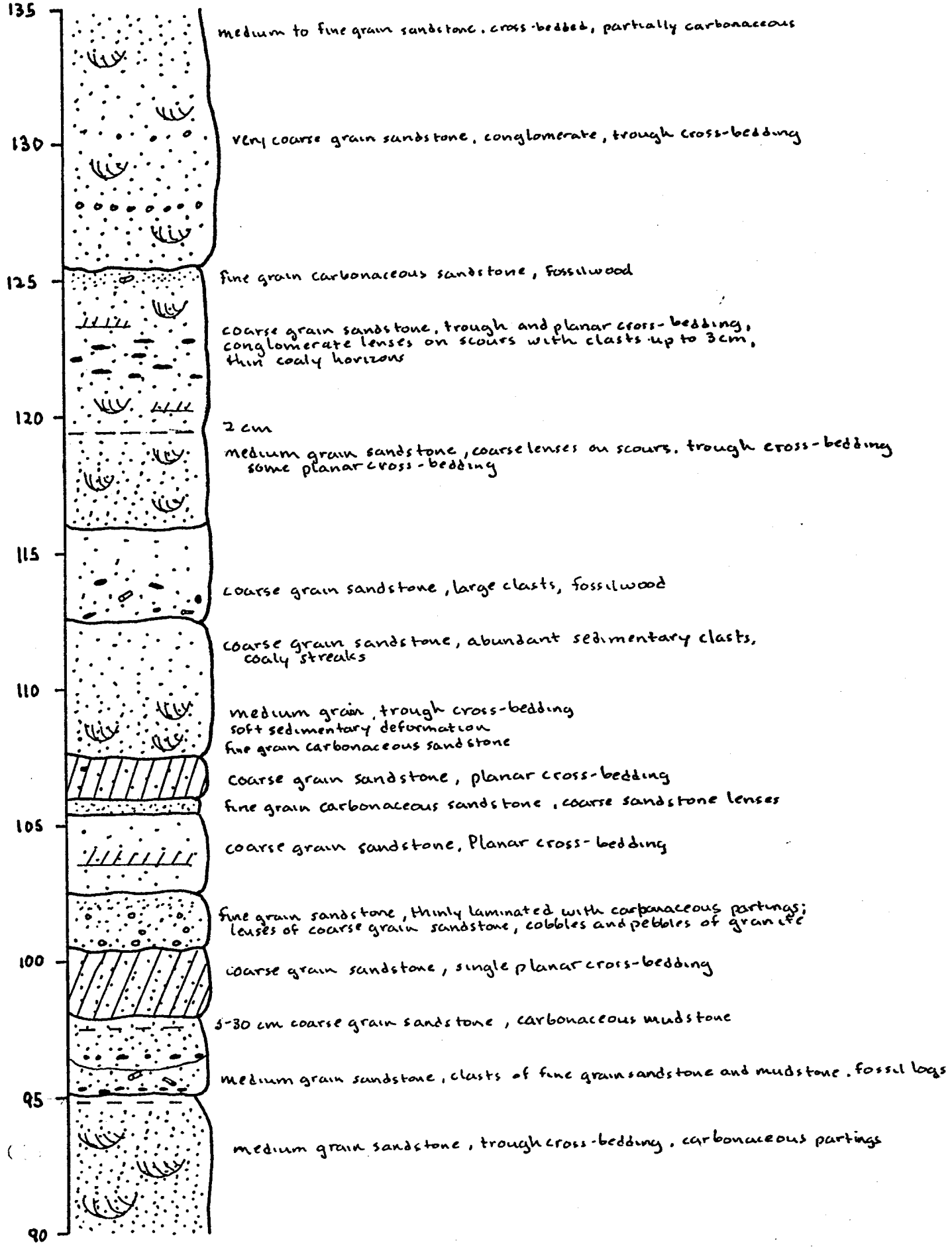
subrounded, well sorted, medium grain sandstone, trough cross-bedding

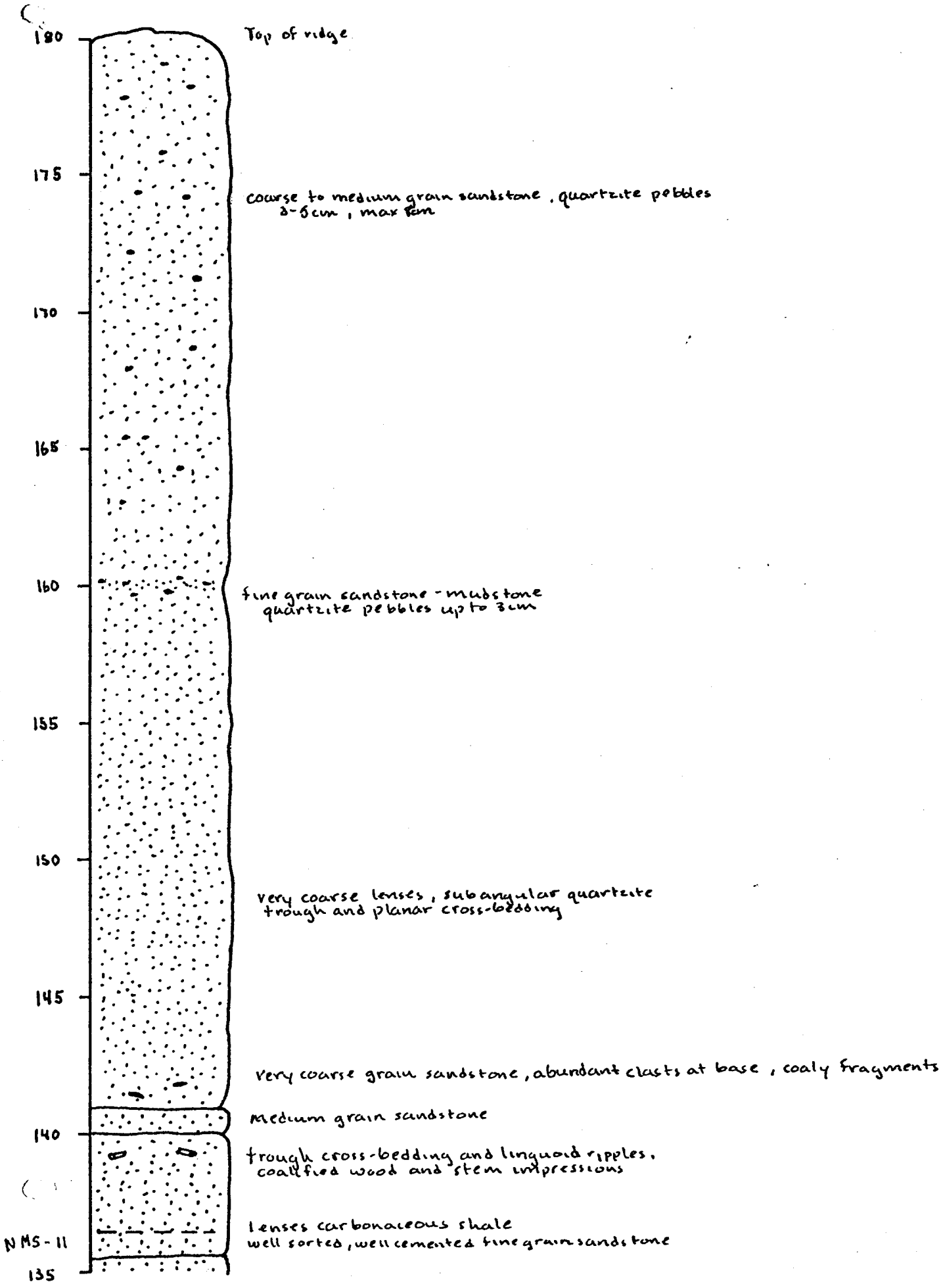
dark gray, carbonaceous shale / changes laterally to boulder-conglomerate channeled into diamictite, samples NMS-BBCC-1, -BBCC-2, -BBCC-3

fine grain sandstone

Below section is 66 m of diamictite, base not seen. Diamictite contains granitic and schist clasts in a fine-grained sandstone-mudstone matrix which is dark-gray to olive-green in color.


90
85
80
NMS-6
75
70
65
60
55
50
45
fine grain sandstone, thinly bedded
medium grain sandstone, trough cross-bedding
coarse grain sandstone, single planar cross-bedding
medium grain sandstone
very coarse grain sandstone, single planar cross-bedding
carbonaceous shale lenses
carbonaceous shale
medium grain sandstone
coarse grain sandstone, subangular, clasts of sandstone and claystone, olive-gray, carbonaceous at base
coarse grain sandstone
30 cm carbonaceous shale
conglomerate lense, mudstone and fine grain sandstone clasts
very coarse grain sandstone, small pebbles common
clay drapes with mudcracks?
fine grain carbonaceous sandstone
coarse grain sandstone
fine grain sandstone
coarse grain sandstone
medium grain sandstone, planar cross-bedding


135
130
125
120
115
110
105
100
95
90
medium to fine grain sandstone. cross-bedded, partially carbonaceous
very coarse grain sandstone, conglomerate, trough cross-bedding
fine grain carbonaceous sandstone, fossil wood
coarse grain sandstone, trough and planar cross-bedding, conglomerate lenses on scours with clasts up to 3cm, thin coaly horizons
2 cm
medium grain sandstone, coarse lenses on scours. trough cross-bedding some planar cross-bedding
coarse grain sandstone, large clasts, fossil wood
coarse grain sandstone, abundant sedimentary clasts, coaly streaks
medium grain, trough cross-bedding
soft sedimentary deformation
fine grain carbonaceous sandstone
coarse grain sandstone, planar cross-bedding
fine grain carbonaceous sandstone, coarse sandstone lenses
coarse grain sandstone, Planar cross-bedding
fine grain sandstone, thinly laminated with carbonaceous partings; lenses of coarse grain sandstone, cobbles and pebbles of granite
coarse grain sandstone, single planar cross-bedding
5-30 cm coarse grain sandstone, carbonaceous mudstone
medium grain sandstone, clasts of fine grain sandstone and mudstone. fossil logs
medium grain sandstone, trough cross-bedding, carbonaceous partings

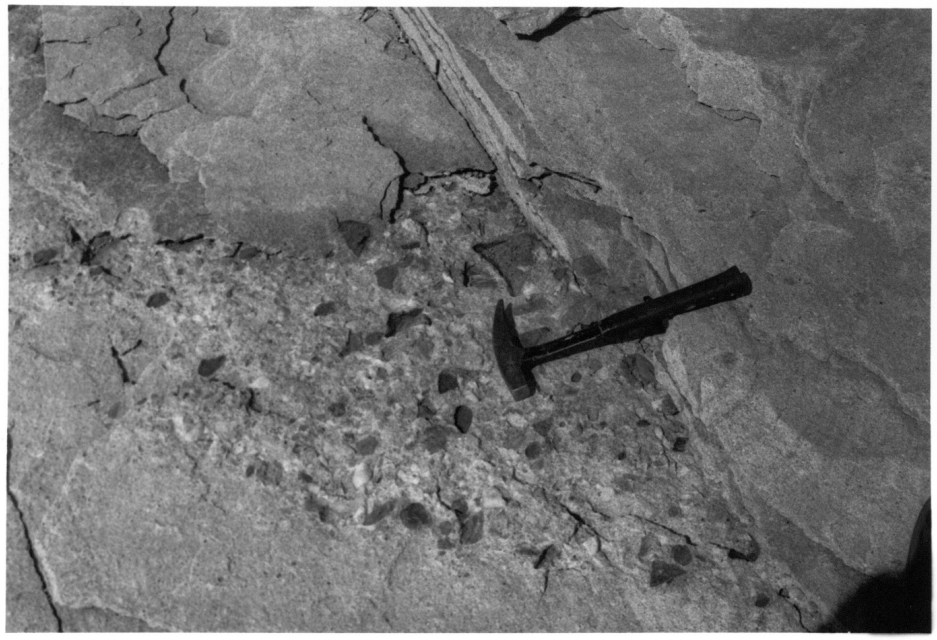

180
175
170
165
160
155
150
145
140
135
NMS-11
Top of ridge
coarse to medium grain sandstone, quartzite pebbles 3-5cm, max 8cm
fine grain sandstone - mudstone quartzite pebbles up to 3cm
very coarse lenses, subangular quartzite trough and planar cross-bedding
very coarse grain sandstone, abundant clasts at base, coaly fragments
medium grain sandstone
trough cross-bedding and linguoid ripples, coalified wood and stem impressions
lenses carbonaceous shale
well sorted, well cemented fine grain sandstone

Neall Massif South
as seen looking south.

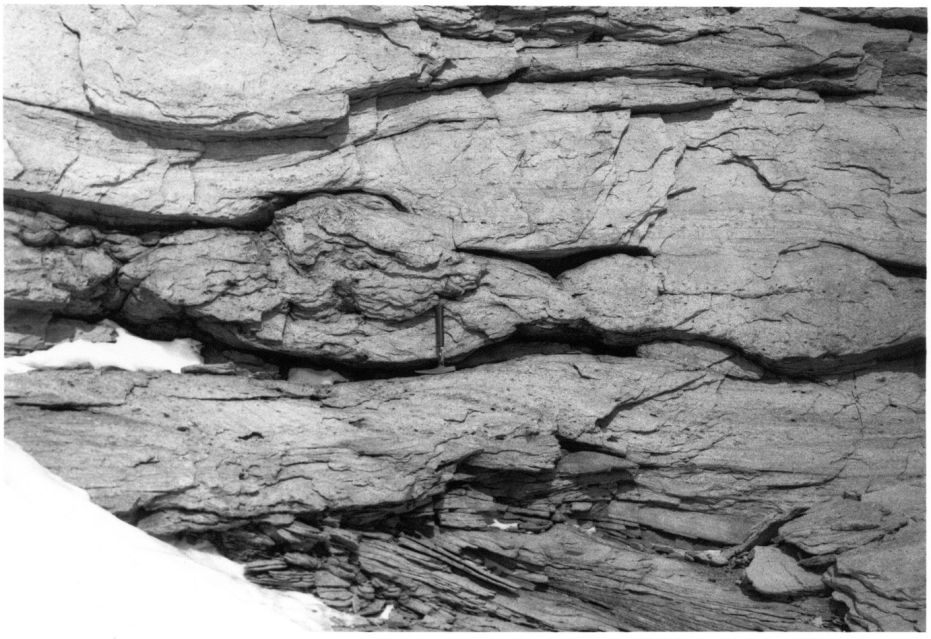
Exposure of basal boulder - cobble conglomerate
near east end of ridge.

Planar cross - bedding
at the 80 m point in the section

Pebble and cobble lens
in fine - grained sandstone
near the 101 m point in the section

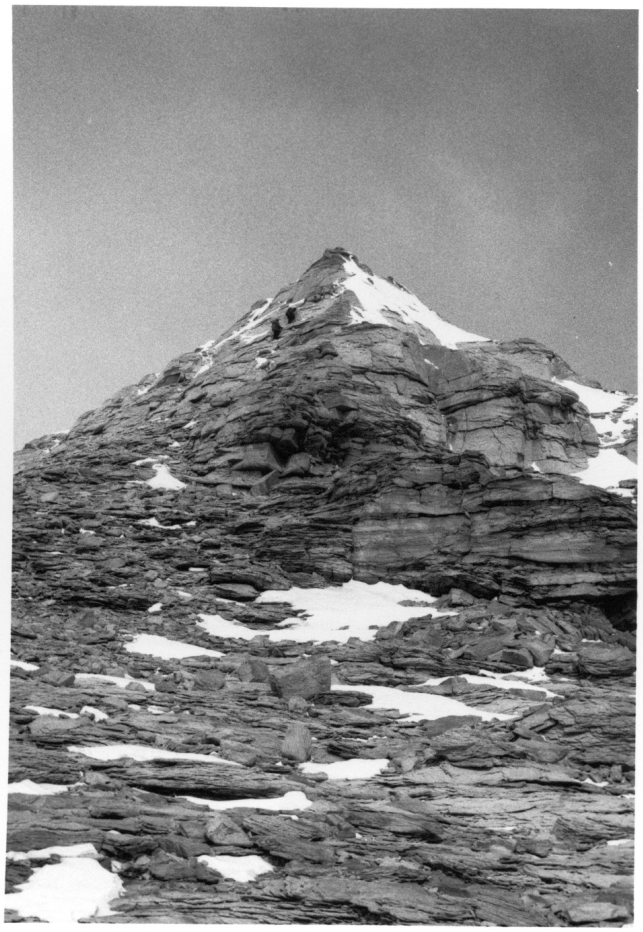


Basal scour with conglomeratic fill,
near the 110 m point in the section.



Basal scour (at hammer head)
near 120 m point in the section.

Large scale trough cross - bedding
in the upper part of the section.



Top of section, mostly coarse - grained sandstone. Two field party members near top for scale.

APPENDIX II

SANDSTONE DESCRIPTIONS

NMS - 3

MEGASCOPIC - a tannish - gray, very coarse - grained sandstone containing white feldspar grains and smoky quartz. Small amounts of whitish clay mineral weathering product are also present.

THIN SECTION - This rock is a poorly - sorted, very coarse - grained arkosic arenite (all classifications are according to Pettijohn, Potter, and Siever, 1972) consisting of subangular grains of feldspar, quartz, and muscovite. These occur in a closely packed framework with interstitial space filled with sericite and authigenic quartz.

FELDSPAR - occurs as equant to elongate grains of low sphericity, up to 4 mm in length. These consist predominantly of microcline, orthoclase, and perthitic grains which show exsolution of albite in microcline. Small amounts of albite - twinned plagioclase are also present which are oligoclase or andesine in composition.

QUARTZ - occurs as commonly fractured, equant grains of moderate sphericity, up to 2 mm in size. Quartz

also occurs as an authigenic interstitial filling.

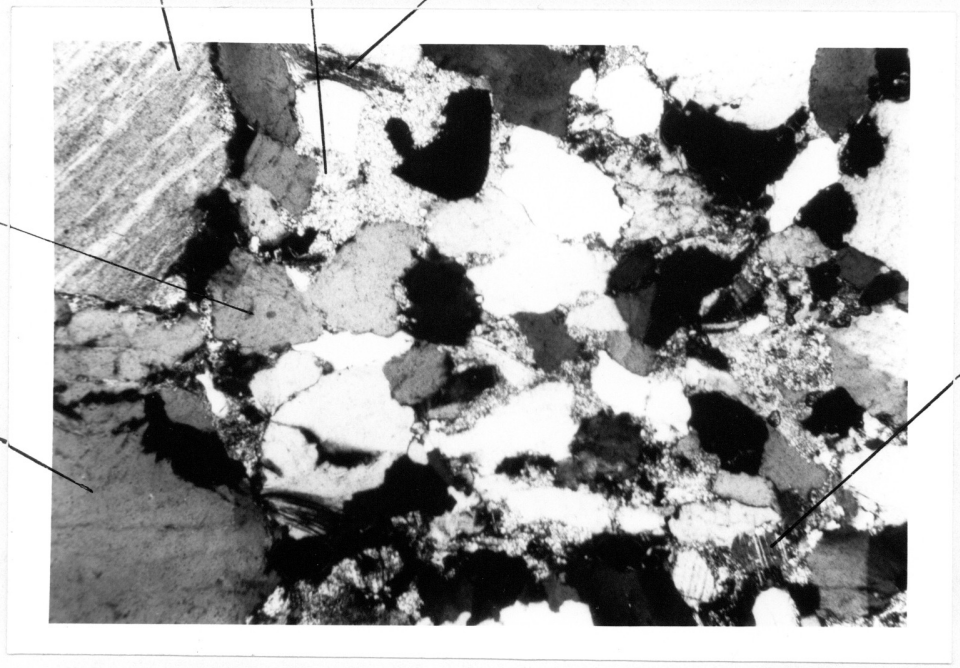
MUSCOVITE - occurs as elongate grains up to 0.2 mm in length and also as inclusions in the feldspars.

SERICITE - occurs in interstices and as alteration product in the feldspars.

CARBONATE - occurs as small interstitial patches as an authigenic mineral.

Estimates made with standard petrographic microscope and using cathodoluminescence:

Quartz.....45%
Potassium Feldspar.....38%
Plagioclase..... 2%
Muscovite..... 6%
Sericite..... 8%
Carbonate..... 1%



NMS - 3, X - Polars

NMS - 5

MEGASCOPIC - a light - tan, coarse - grained, well consolidated sandstone which contains grains of whitish feldspar, smoky quartz, and fragments of muscovite.

THIN SECTION - This rock is a well - sorted, coarse - grained arkosic arenite consisting of subangular grains of feldspar and quartz, and lesser amounts of muscovite, sericite, and carbonate. These form a closely packed framework with interstitial space filled with sericite and secondary quartz.

FELDSPAR - occurs as equant grains of moderate - to low - sphericity which generally have a cloudy appearance due to alteration. These are most commonly orthoclase of microcline grains which are up to 1.8 mm in length. Perthitic grains showing exsolution of albite in microcline are also present. A small amount of plagioclase is present in small, albite - twinned grains, generally around 0.4 mm in size. Some of these feldspar grains show slight alteration to sericite.

QUARTZ - is present as detrital grains up to 1.25 mm in size, and as authigenic interstitial fillings. Detrital grains occur as fractured, equant grains of moderate sphericity.

MUSCOVITE - occurs as elongate grains up to 0.5 mm in length, but more commonly as smaller fragments.

SERICITE - occurs as small patches of alteration product in the feldspar and as interstitial filling.

CARBONATE - occurs as small interstitial patches as an authigenic mineral.

Estimates made with standard petrographic microscope and using cathodoluminescence:

Potassium Feldspar.....38%

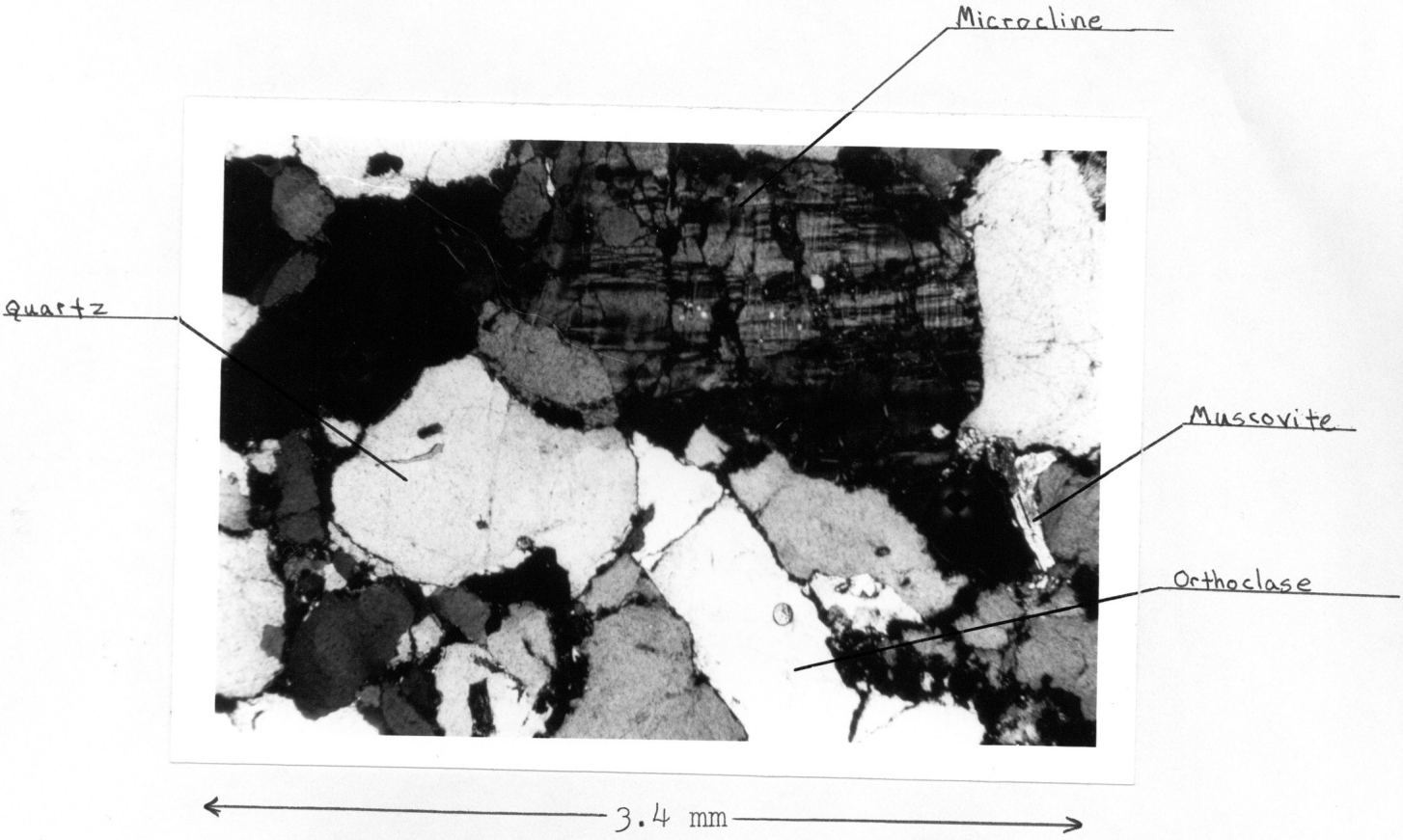
Quartz.....55%

Plagioclase..... 2%

Carbonate..... 3%

Muscovite..... 1%

Sericite..... 1%



NMS - 5, X - Polars

NMS - 6

MEGASCOPIC - a light - tan very coarse - grained well cemented sandstone which contains whitish - gray feldspar grains up to 5 mm in length. Colorless and smoky quartz are abundant. Slight weathering has produced small amounts of a clay mineral.

THIN SECTION - This sample is a coarse - grained, moderately-sorted, arkosic arenite composed primarily of subangular feldspar and quartz grains. There are also minor amounts of biotite, muscovite, garnet, and sphene present. These form a tightly - packed framework whose interstitial space is filled with a mixture of sericite and authigenic quartz.

FELDSPAR - occurs as equant to elongate grains of low to moderate sphericity up to 2.5 mm in size. These are composed primarily of potassium feldspar grains of orhtoclase and microcline. Perthitic grains showing exsolution of albite in a microcline host are also common. Small amounts of albite - twinned plagioclase of andesine composition are also present.

QUARTZ - occurs as equant grains of moderate sphericity up to 1.8 mm in size. In some cases these contain small inclusions of muscovite. Quartz also occurs

in minor amounts as authigenic interstitial filling.

MUSCOVITE - occurs sparsely as small elongate grains up to 0.4 mm in length. These grains usually occur interstitial to the larger feldspar and quartz grains, but they can also be found as inclusions in them.

BIOTITE - occurs as small tabular grains up to 0.4 mm in size. These occur interstitial to the larger feldspar and quartz grains, and are pleochroic from brown to light brown.

SPHENE - occurs as rare angular, broken, and fractured crystals up to 0.2 mm in length. These have high relief and show extreme birefringence.

GARNET - occurs rarely as rounded isotropic grains with high relief. These are up to 0.8 mm in diameter.

SERICITE - occurs in small amounts as interstitial filling and as small patches of alteration product in the feldspars.

CARBONATE - occurs in small interstitial patches as an authigenic mineral.

Estimates made with standard petrographic microscope and using cathodoluminescence:

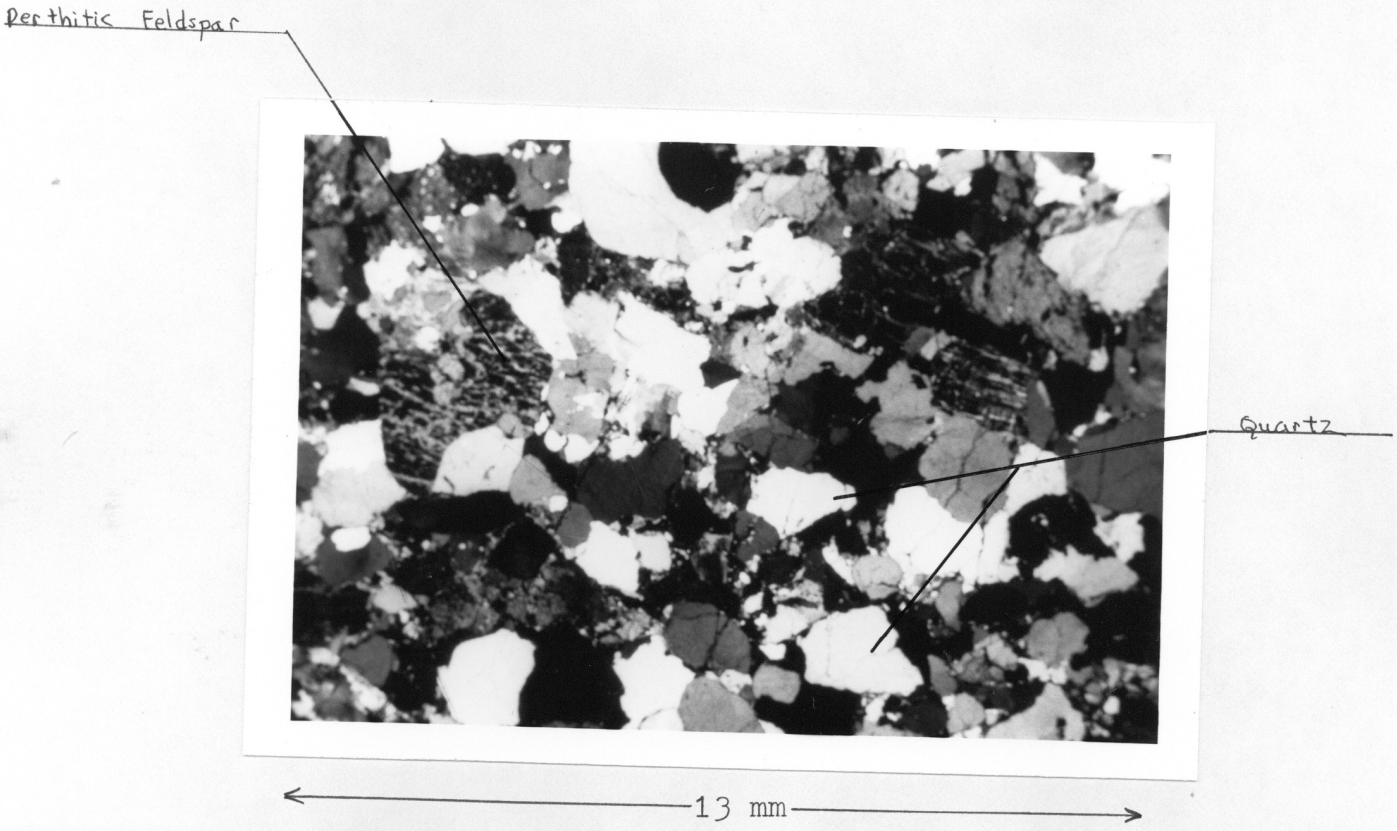
Quartz.....47%

Potassium feldspar....45%

Plagioclase..... 2%

Muscovite..... 3%

Biotite and others.... 3%



NMS - 6, X - Polars

NMS - 11

MEGASCOPIC - a whitish - gray, medium - grained, well cemented sandstone which contains grains of white feldspar and smoky as well as colorless quartz.

THIN SECTION - This sample is a well - sorted, medium - to coarse - grained arkosic arenite composed of subangular - to subrounded - grains of feldspar and quartz. There are also minor amounts of muscovite and biotite present. These grains occur in a closely packed framework with little interstitial space. Interstitial space is generally filled with a mixture of sericite and authigenic quartz along with minor amounts of authigenic calcite.

FELDSPAR - occurs as low sphericity equant - to elongate - grains generally about 0.5 mm in size. Some of these grains show slight alteration to sericite. Potassium feldspar is most predominant being represented by orthoclase, microcline, and anorthoclase grains. There are also small amounts of albite - twinned plagioclase present. This is andesine in composition.

QUARTZ - occurs as equant grains of moderate - sphericity. These are generally around 0.5 mm in size and commonly fractured. Quartz is also seen as an authigenic interstitial filling.

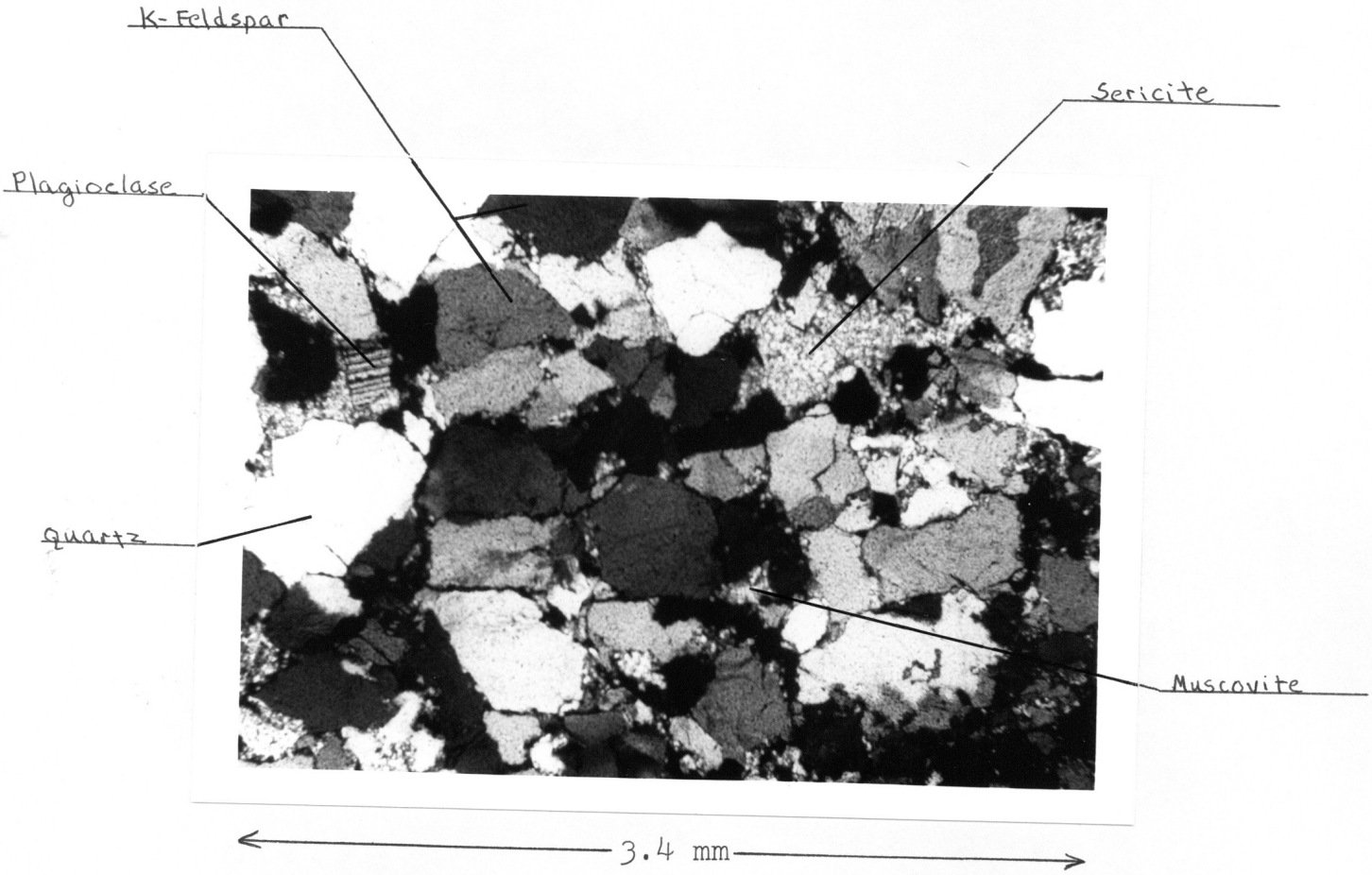
MUSCOVITE - commonly occurs as small interstitial grains or as inclusions in the quartz and feldspar grains. Some of these grains are up to 0.3 mm in length. These show slight alteration.

BIOTITE - occurs in minor amounts as elongate pleochroic grains generally about 0.1 mm in length. These occur interstitial to the quartz and feldspar grains and are commonly altered to chlorite.

SERICITE - occurs as an interstitial filling and as small patches of alteration product in the feldspar.

Estimates made with standard petrographic microscope and using cathodoluminescence:

Quartz.....45%
Potassium feldspar.....40%
Plagioclase..... 2%
Muscovite..... 5%
Sericite, Carbonate.... 8%



NMS - 11, X - Polars

APPENDIX III

DESCRIPTIONS OF CLASTS FROM THE BASAL BOULDER - COBBLE CONGLOMERATE

The clasts from the basal boulder - cobble conglomerate have a leucocratic appearance and sugary texture. These contain white feldspar grains, smoky quartz and occassionally pale green epidote. These aplites are fine - to medium - grained with crystals up to 3 mm in length. Alternating bands of fine and medium grained crystals are observed in some samples. Samples are weathered to different degrees. The weathering product is a white to gray clay mineral.

NMS - BBCC - 1

THIN SECTION - This rock is a medium - grained, holocrystalline allotriomorphic - granular aplite which contains quartz, perthitic feldspar, and small amounts of biotite, muscovite, epidote, and sericite.

FELDSPAR - subhedral perhtite crystals up to 3.75 mm in length. These grains show Carlsbad - twinning and are commonly altered to sericite. The perthitic texture is formed by exsolution of plagioclase in a microcline host.

QUARTZ - occurs as anhedral fractured crystals up to 5 mm in size.

BIOTITE - occurs as elongate subhedral crystals up to 1.25 mm in length. These grains are pleochroic from brown to light - brown, but are commonly altered to chlorite which has a green to light - green pleochroism.

MUSCOVITE - occurs sparsely as small subhedral crystals up to 0.3 mm in length. These are usually as inclusions in other grains.

EPIDOTE - subhedral to euhedral crystals which commonly occur together in a radiating habit. These crystals are generally about 0.1 mm in length, green - yellow in color, and typically occur in densely packed groups. These groups appear to be included in other crystals but they commonly overlap host - grain boundaries.

CHLORITE - almost totally replaces most of the biotite crystals. This chlorite is pleochroic from green to light - green.

SERICITE - occurs as discontinuous patches in the feldspar and as veins in the quartz. Also appears with quartz microlites in replacement of older grains.

Estimated composition:

Feldspar.....55%

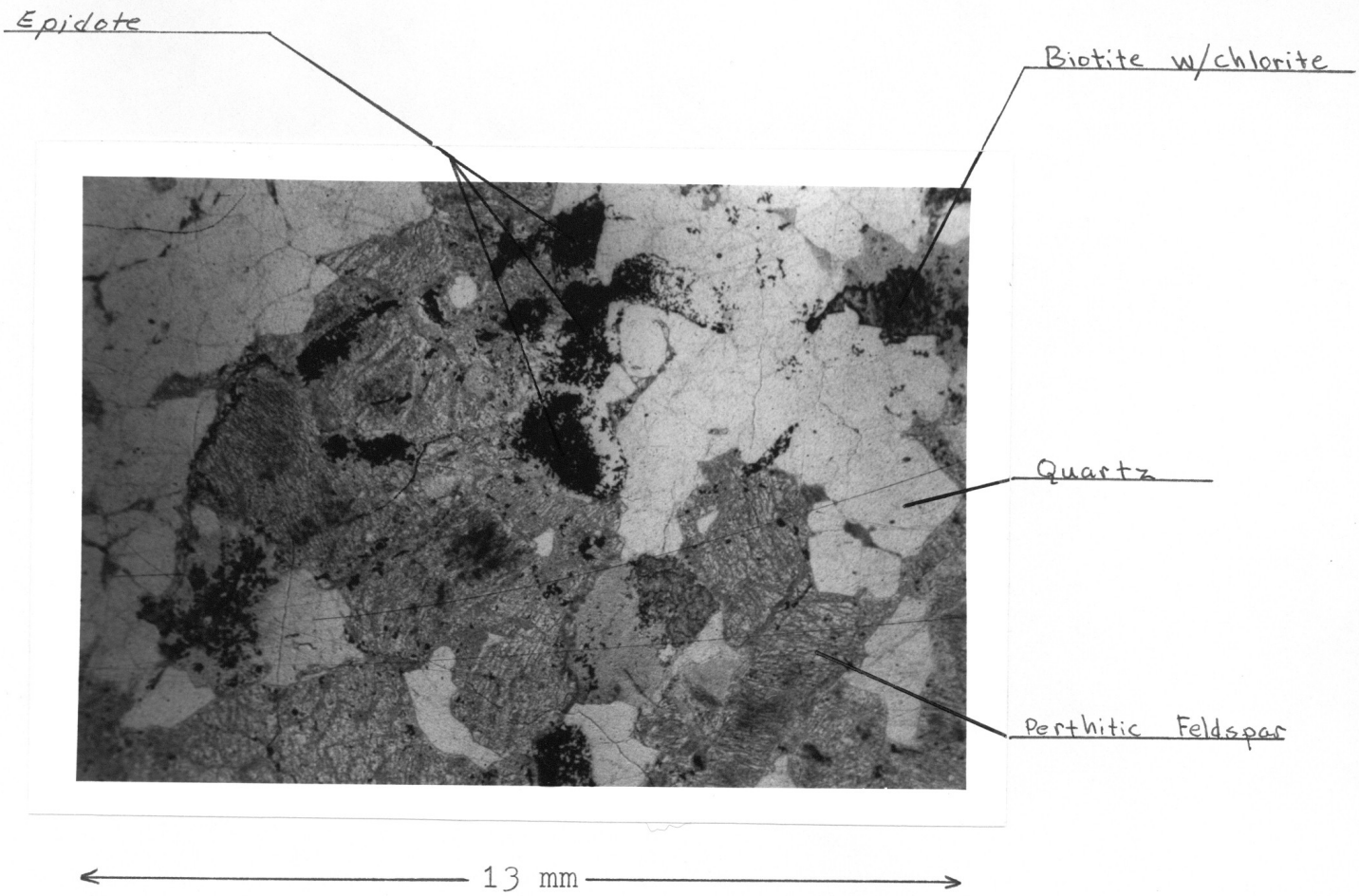
Quartz.....20%

Biotite with Chlorite..13%

Muscovite..... 1%

Epidote..... 5%

Sericite..... 6%



NMS - BBCC - 1, Normal light

NMS - BBCC - 2

THIN SECTION - This sample is a medium - grained, holocrystalline allotriomorphic - granular aplite which contains quartz, perthitic feldspar, plagioclase, biotite, and minor amounts of muscovite and sericite.

FELDSPAR - occurs as subhedral plagioclase and perthite crystals up to 1.25 mm in length. The plagioclase is andesine in composition, shows Carlsbad - albite twinning, and is commonly altered to sericite. The perthite, which shows exsolution of albite in a microcline host, is also partially altered to sericite. Microcline not showing exsolution features is also present in crystals up to 1 mm in size.

QUARTZ - occurs as grains up to 1 mm in size, and as interstitial microlites.

BIOTITE - occurs as subhedral grains up to 0.4 mm in length and is pleochroic from light - green to green.

MUSCOVITE - occurs as small subhedral crystals up to 0.2 mm in length. These generally occur as inclusions in the quartz an feldspar crystals.

SERICITE - is found as isolated patches and veinlets in the feldspar crystals.

Estimated composition:

Potassium Feldspar.....22%

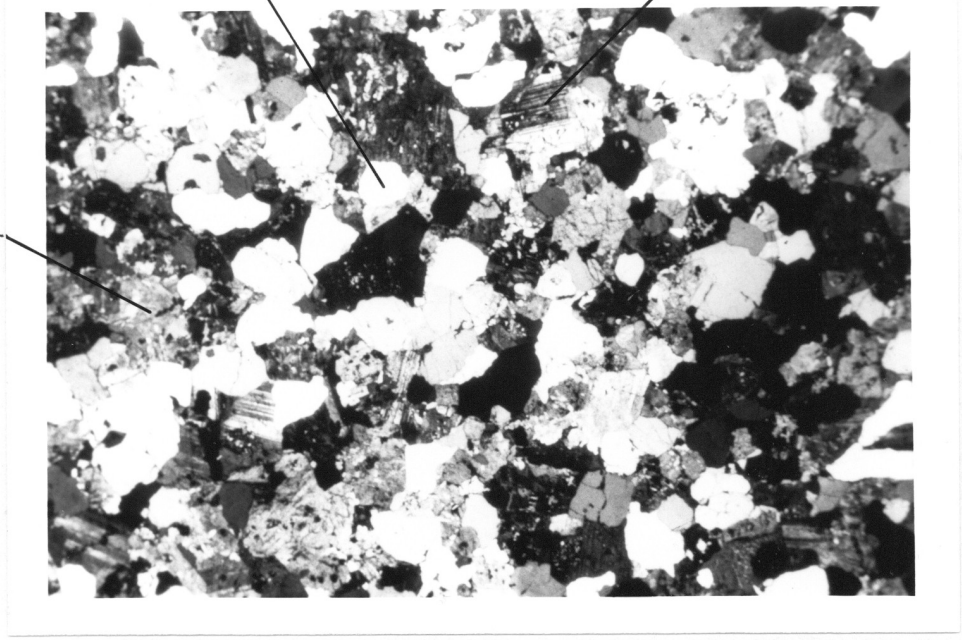
Plagioclase.....55%

Biotite.....10%

Quartz..... 9%

Sericite..... 3%

Muscovite..... 1%



13 mm

NMS - BBCC - 2, X - Polars

NMS - BBCC - 3

THIN SECTION - This rock is a medium - grained, holocrystalline, allotriomorphic - granular aplite consisting primarily of quartz, plagioclase, and perthitic potassium feldspar. There are also minor amounts of biotite, muscovite, and alteration product present.

FELDSPAR - most commonly occurs as perthitic potassium feldspar crystals. These show exsolution of albite in a microcline host and are up to 3.5 mm in length. Smaller amounts of plagioclase are also present occuring as anhedral crystals up to 2 mm in length. These are andesine in composition and show Carlsbad albite twinning.

QUARTZ - occurs interstitally in patches up to 1.2 mm in length.

BIOTITE - occurs as subhedral ragged crystals up to 1.2 mm in size. These are pleochroic from green - brown to light - green and are commonly altered to chlorite.

MUSCOVITE - occurs as small subhedral crystals generally around 0.1 mm in size. These typically occur as inclusions in the feldspar grains.

ALTERATION PRODUCTS - sericite occurs as patchy areas in the feldspar grains. Chlorite occurs commonly replacing biotite.

Estimated composition :

Potassium Feldspar.....50%

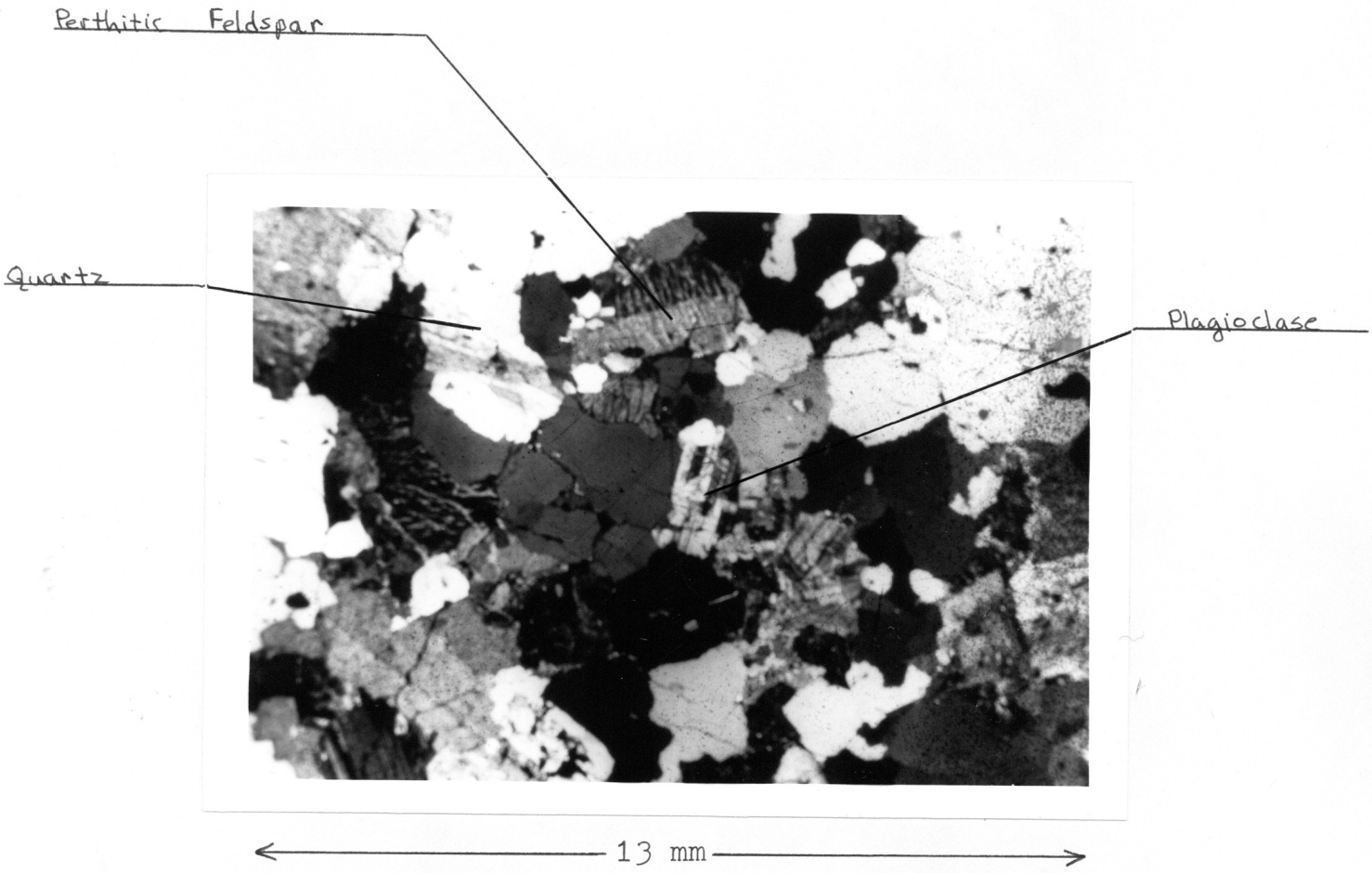
Plagioclase.....25%

Quartz.....10%

Biotite.....11%

Muscovite..... 3%

Sericite, Chlorite..... 1%



NMS - BBCC - 3, X - Polars

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